
Space Weather Technical Forecast

Issued on Saturday, 06 January 2024 at 13:08 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of M-flares with a slight chance of X-flares. CME arrival forecast on late 07 or 08 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Low, with a peak C5.2 flare observed at 05/0809 UTC from AR3536 close the centre limb. This is one of a number of C-class flares from AR3534, AR3536 and AR3540, which is currently rotating around the southeast limb.

There are currently eleven sunspot regions on the visible disc, three of which are unnumbered. Region AR3540 near the eastern limb is currently the largest area on the disc and may contain a delta region in its leading spot, although confidence is low due to possible foreshortening due to its proximity to the eastern limb and will need further analysis before this is confirmed. AR3536 is also a magnetically complex region, which is north-south aligned, and contains a small persistent delta region. AR3538 in the northwest has shown some enhancement and has a fairly complex magnetic configuration, albeit most of its spots look relatively small. The two new unnumbered spots on the disc close to the far east will become easier to analyse once they rotate away from the eastern limb. All remaining spots appear unchanged and magnetically simple.

A CME was observed leaving the region of AR3536 at around 04/2300UTC appears to have an Earth-directed component. A further CME observed at around 05/0100UTC appears to have emanated from close to the southeast limb and may have left from the newly emerging region on the limb. A filament eruption observed at 06/0620 likely produced a CME that will be analysed once it is visible in imagery.

Solar Wind / Geomagnetic Activity: Solar winds have been slightly elevated at 420-480km/s according to DSCOVR, but it should be noted ACE is reading background levels at around 380km/s so there is significant uncertainty regarding current solar wind speeds. Density has been around average or slightly below. Total interplanetary magnetic field strength, IMF, has been weak, with the north-south component varying weakly. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity has been Quiet (Kp0-2) throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux peaked at 6.27pfu at 05/1220 and has been on a gradual decline since. GOES16 high energy (greater than 2MeV) electron flux was at background levels. The 24-hour fluence was below Active throughout, with a flat trend. The 06/0000 UTC observation was 2.06e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is forecast, with a slight chance of X-class flaring.

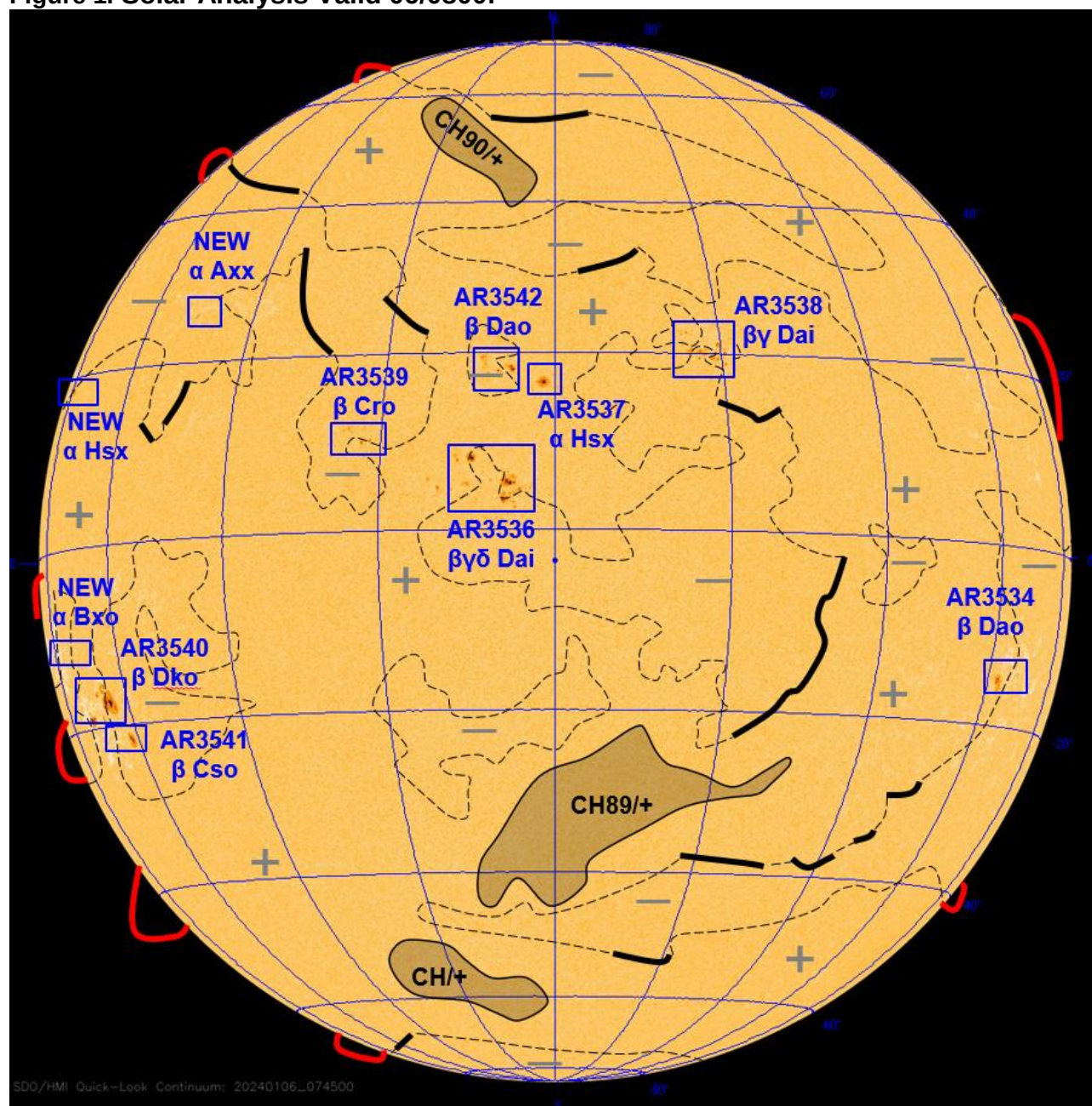
Solar Wind / Geomagnetic Activity: A CME which left the Sun from the northeast quadrant late on 04 January may glance the Earth either late on Day 2 (07 Jan) or during Day 3 (08 Jan). A filament eruption observed at 06/0620 likely produced a CME that will be analysed once it is visible in imagery. Solar wind speeds are expected to decline to background, with a high speed stream from coronal hole 89 forecast to connect with the Earth either late on Day 2 (07 Jan) or during Day 3 (08 Jan), with estimated speeds of 400-500km/s. Geomagnetic activity is forecast

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to start Quiet on Day 1 (06 Jan). Unsettled to Active intervals are then possible on Days 2 to 4 (07-09 Jan), with a slight chance of G1/Minor Storm intervals due either to the high speed stream, CME or a combination of both.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is below the S1/Minor Storm threshold. This is expected to follow a declining trend, but with a risk of further increases above the threshold on 07 or 08 January due to the CME arrival. GOES16 high energy electron flux is likely to remain at predominantly background levels at first, with a chance of Moderate levels later in the period, dependent on the interaction of the coronal hole high speed stream connection and CME arrival, which may keep electrons suppressed throughout the period.

Figure 1. Solar Analysis Valid 06/0800.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

Two CMEs have been analysed in the last 24 hours. One was on the eastern limb and is not expected to affect the Earth. A further CME from the northeastern quadrant is forecast to perhaps glance the Earth either late on Day 3 (08 Jan) or during Day 4 (09 Jan), although this is low confidence. A filament eruption observed at 06/0620 likely produced a CME that will be analysed once it is visible in imagery.

Otherwise, Solar wind speeds are expected to decline to background through the rest of Day 1 (06 Jan). The high speed stream from coronal hole 89 may then connect with the Earth on Day 2 (07 Jan), with speeds in the region of 450-500km/s possible, these then continuing into Day 3 (08 Jan) and slowly waning into Day 4 (09 Jan). This coronal hole is a recurrent feature which produced limited effects on the previous rotation, but which appears to be stronger on this rotation. As the coronal hole high speed stream and CME are forecast to affect the Earth around the same time, there is uncertainty about potential speeds, with the speed of the CME also forecast at around 400-450km/s.

Geomagnetic activity is forecast to be mainly Quiet on Day 1 (06 Jan). There is then a slight chance of Unsettled to Active periods and a very slight chance of G1/Minor storms on Days 2 -4 (07-09 Jan) due to the potential coincident arrival of the high speed stream and CME.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	15	15	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
05/0986	05/0986	05/0986	05/0986	05/0986	05/0986	05/0986

Figure 2: MOSWOC Enlil model showing the anticipated time of CME arrival (highlighted by yellow circle).

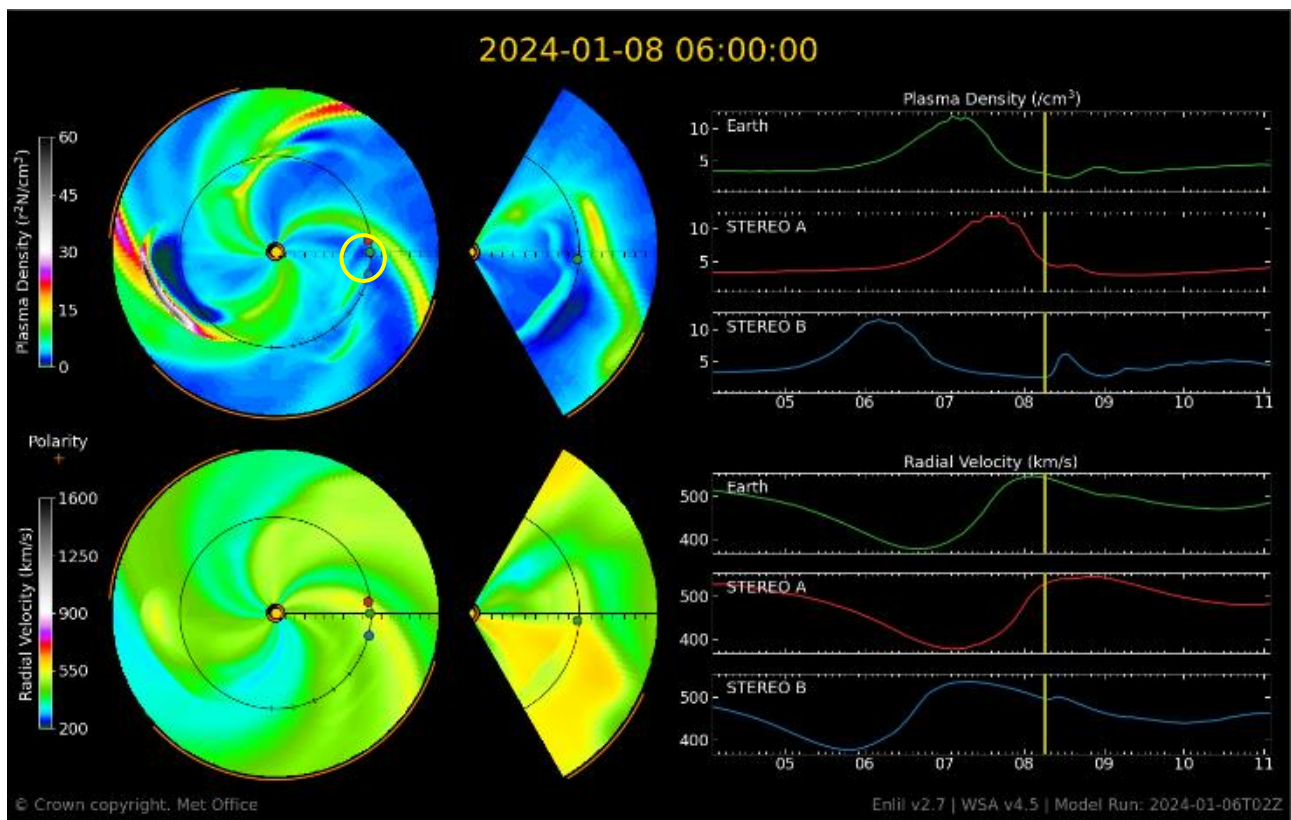
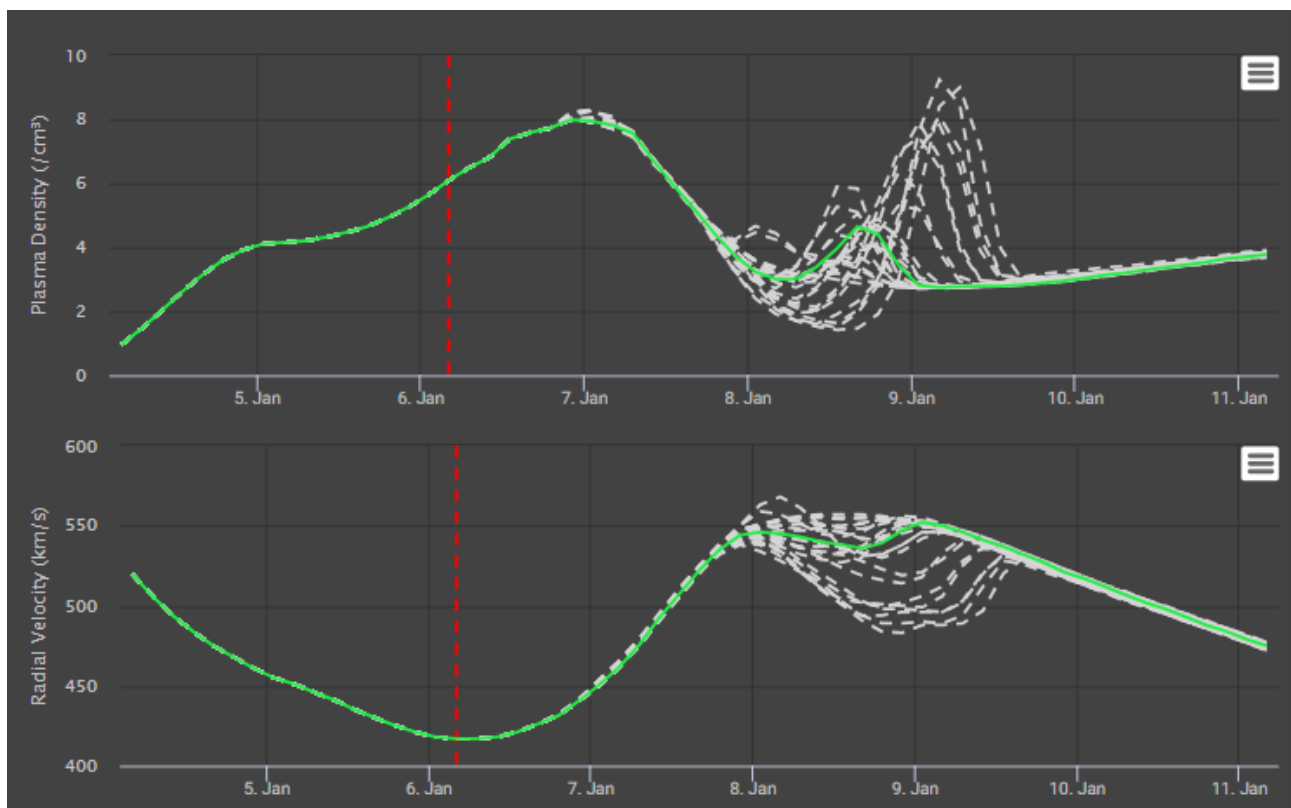


Figure 3: MOSWOC Enlil ensemble shows the range of CME arrival times.



Radio Blackouts - X-Ray Flares:

Activity has been Low over the last 24 hours with the majority of activity observed from AR3534, AR3536 and AR3540, which is rotating onto the southeast quadrant. A filament eruption close to AR3536 early on 06 January, was associated with a C-class flare, which appears to have an Earth-directed component, although further analyses will be required as more imagery becomes available.

AR3536 is the most complex region on the disc with a persistent Delta spot in the central region, which appears to be a north-south alignment, with still enough energy to produce a significant flare. AR3538 in the northwest is also complex with a beta-gamma configuration but is less active.

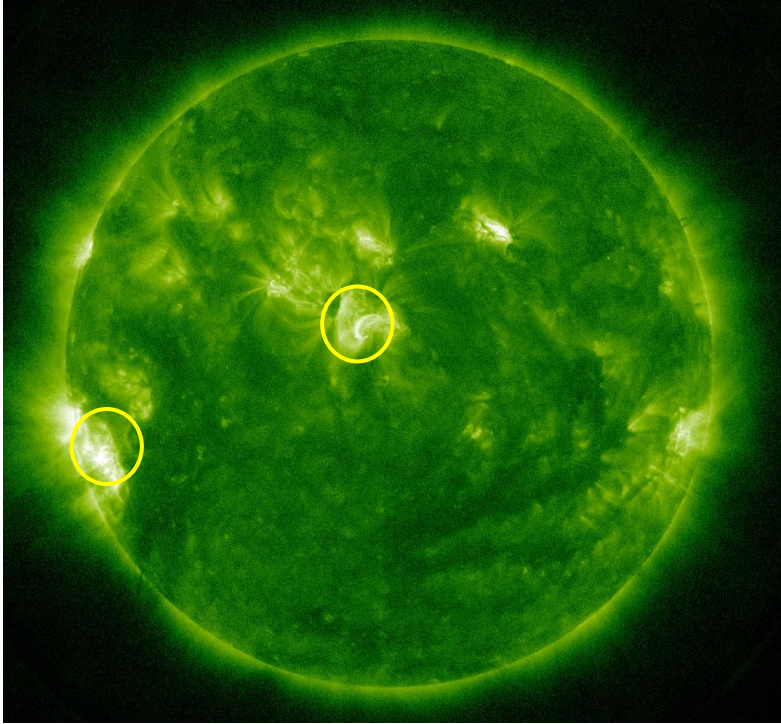
AR3540 which is currently rotating onto the southeast disc is the largest area on the disc and shows some magnetic complexity and may contain a delta region in its leading spot, although this is difficult to ascertain at present due to its viewing angle and may just be a result of foreshortening. The southern portion of this region has separated and is now the newly numbered AR3541, which shows a simpler HSX/Alpha configuration. However, the close proximity of the two ARs may still produce a significant flare. There appears to be a lot of magnetic looping evident in the SDO/AIA 171 imagery above these two regions in the southeast.

Low to Moderate activity is forecast with a M-flares likely at times with a slight chance of an X-class flare, mainly from AR3536 in the northeast and from AR3540 in the southeast.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 4: SDO-AIA 94 Imagery with two most active regions circles

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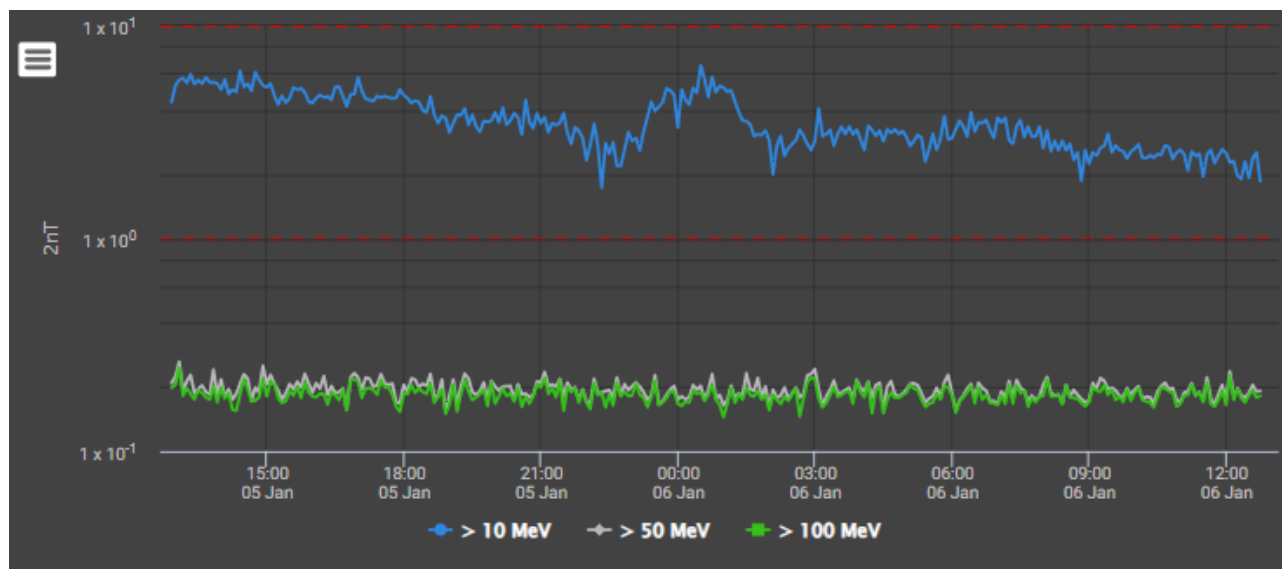
Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux is currently below the S1/Minor Storm threshold, on a steady downward trend, with only a slight change of brief increases above the S1/Minor Storm level during Day 1 and Day 2 (06-07 Jan).

There appears to have been a slight increase in low energy protons observed at ACE following the CME from the northeast quadrant. This CME is due to glance the Earth on 08 or 09 January, giving a chance of further proton enhancements.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	20	20	30	30
Very Active	$\geq \text{S3}$ *	No	1	1	1	1
* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

Figure 5: GOES-16 Proton flux



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) is expected to be at background levels through Day 1 (06 Jan) in the presence of a benign solar wind environment. Uncertainty increases through Day 2-4 (07-09 Jan) as a potential coincident high speed stream and CME arrival could lead to an eventual increase in the electron flux. However, the precise timing and strength of each of the events will determine the timeline of increase and decreases in electron flux values.

Electron fluence values are well below the Active threshold. A rising trend may become evident later in the period should there be a sustain rise in flux levels. This is however subject to low confidence.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	5
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 6: MOSWOC REFM electron fluence

